When does the turning point in China's CO_2 emissions occur?

Results based on the Green Solow Model

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ONLINE APPENDIX

Comparisons of our forecast results with historical experiences and some other forecast results

To date, several developed economies have experienced a turning point in CO_2 emissions. It is meaningful and interesting to compare the forecasted turning point of China's CO_2 emissions and economic development status with several representative developed economies. The comparisons are presented in table A1.

As shown in table A1, at the time when total CO_2 emissions peak, China's projected total CO_2 emissions will be much higher than the peak emissions of the representative economies, while China's per capita peak CO_2 emissions will be relatively moderate. At the turning point in total CO_2 emissions, although China's per capita CO_2 emissions will be lower than those of the U.S. and Germany, China's per capita CO_2 emissions will be higher than those of France, the United Kingdom and Taiwan, China. The comparison indicates that China may be able to control its CO_2 emissions in the process of industrialization, given that China's share of global CO_2 emissions is much greater than its share of world GDP (see figure 1). In addition, China would see its total CO_2 emissions peak at a time when its economic growth rate is still predicted to be moderately rapid. In fact, at the time when the turning point in total CO_2 emissions is reached, China will still have substantial time before it arrives at its steady state as predicted by the GSM. In the benchmark scenario, in 2070, China's GDP growth rate will be approximately 3.4 per cent, which is still fairly higher than China's steady-state growth rate of 2.6 per cent.

To date, several other studies have made forecasts for the turning point in China's CO_2 emissions. In table A2, some representative forecasts from other studies are listed.

Table A1. *Comparisons of some important indicators at the time when the turning point of total CO_2 emissions occurs in China with some representative developed economies*

Country/Region	Time of the turning point in total national CO_2 emissions	Total CO_2 emissions at the turning point (million tons)	Per capita CO_2 emissions at the turning point (kg)	Per capita GDP at the turning point (U.S. dollars, 2000 constant price)	GDP growth rate at the turning point
China	2047	22622	13891	31795	4.4%
Germany	1976	1093	13958	14641	2.7%
France	1979	529	9644	15619	1.9%
United Kingdom	1971	661	11815	13134	3.8%
United States	2005	5841	19749	37206	2.9%
Taiwan, China	2007	275	12018	17668	2.5%

Note: Considering the economic fluctuations, the GDP growth rates of all other countries at the turning point time T are calculated as the average GDP growth rates between the years T-2 and T+2. For example, the German GDP growth rate in 1976, when the total CO_2 emission peaked, is calculated as the average of the German GDP growth rates between 1974 and 1978.

Sources: The CO_2 emissions data are from CDIAC. The population data for developed economies are from the World Bank Database. China's per capita GDP is calculated based on a fixed exchange rate in 2000, whereas the real per capita GDP series of other developed economies are from the ERS International Macroeconomic Data Set. The GDP growth rates are calculated by the authors.

Table A2. *Comparison of forecast results for the turning point in China's total CO_2 emissions*

Researcher	Model or method used for forecast	Time of the turning point in total national CO_2 emissions	Total CO_2 emissions at the turning point (million tons)	Per capita CO_2 emissions at the turning point (kg)	Per capita GDP at the turning point (U.S. dollars, 2000 constant price)	GDP growth rate at the turning point
Authors	Green Solow Model	2047	22622	13891	31795	4.4%
Auffhammer and Carson (2008)[a]	Empirical test for CKC	2056			26926	
Xu and Song (2010)	Empirical test for CKC	2027			14249	5.7%
Zhu et al. (2009)	Improved Moon-Sonn (1996) model	2040	13460	7648	14104	5.07%
Chinese Academy of Sciences (2009)[b]	IPAC model	2040	12925	8793	12843	4.98%
UNDP China (2010)[c]	PECE model	2050	16200	10800	14853	3.5%

Note: The forecast calculations are all performed under the benchmark scenario.

[a] Based on the regression result for model (2) in table 1 of the original research. To calculate the time at which the turning point in CO_2 emissions would be reached, the per capita real GDP growth rate is assumed to be 6% after 2003 (the initial time of the forecasts in the original research).

[b] Under the benchmark scenario, per capita GDP growth rate is 6.4% between 2005 and 2040. In the strong abatement scenario, the turning point comes at the year 2030 and peaks at CO_2 emissions of 8169 million tons.

[c] Under the benchmark scenario, the turning point in total CO_2 emissions would not occur before 2050. Only in the strong abatement scenario would the CO_2 emissions peak before 2050, and the total CO_2 emissions would peak in approximately 2030, at 8800 million tons. The predicted per capita GDP at the turning point is measured at the 2005 constant price.

The forecasts presented in table A2 can be classified by forecasting methodology into three categories. Our forecasts and Zhu *et al*.'s (2009) predictions are on the basis of specific growth models. The forecasts made by Auffhammer and Carson (2008) and Xu and Song (2010) are based on the empirical estimations of China's EKC for CO_2 emissions. The forecasts made by the Chinese Academy of Sciences (2009) and UNDP China (2010) are based on scenario analyses.

As shown in table A2, the forecasted time of the turning point, the total CO_2 emissions and the corresponding economic indicators (per capita GDP and GDP growth rate) at the time when peak CO_2 emissions occur vary considerably in different studies. The predicted time for the turning point in our research is similar to that of Zhu *et al*. (2009), whereas our per capita CO_2 emissions forecasted are close to those projected by UNDP China (2010). However, compared with other studies, our forecast has several significant advantages. First, our forecast employs the GSM as a solid theoretical basis. As mentioned previously, the empirical estimations of CKC have some major problems and may lead to unreliable forecast results. Another practical problem is that the maximum CO_2 emissions at the turning point are difficult to predict because the values of some other indicators used as regressors at the time of the turning point also have to be forecasted, which is generally highly subjective and therefore unreliable. This is the case for Auffhammer and Carson (2008) and Xu and Song (2010). Second, our forecast is based on the estimations of a set of basic parameters (α, s, δ, θ, n, g_A, and g_B) that describe the fundamental characteristics of China's economy, whereas the forecasts based on scenario analyses (such as those made by the Chinese Academy of Sciences (2009) and UNDP China (2010)) may to a great extent depend on some arbitrary assumptions regarding future economic situations (such as economic growth rate, energy consumption intensity, etc.). Third, our forecast is continuous in time, which means that the dynamics of the total and per capita CO_2 emissions can be forecasted before and after the occurrence of the turning point (as shown in figure 4). As a result, our forecast provides a more complete image of China's future CO_2 emissions roadmap than the forecasts based on scenario analyses, which are usually calculated for discrete time points and therefore can only describe the predicted status of China's CO_2 emissions at certain specific times.

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